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USAFOEHL REPORT

81-09

MERCURY VACUUM CLEANER, OPERATIONAL TEST AND EVALUATION

MARCH 1981

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235-5501

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JOHN J. COUGHLIN, Colonel, USAF, BSC
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REPORT NO. 81-09

MERCURY VACUUM CLEANER,

OPERATIONAL TEST AND EVALUATION

MARCH 1981

Prepared by:

RODNEY C. BENNETT, 1Lt, USAF, BSC
Bioenvironmental Engineer

Reviewed by:

JAMES C. ROCK, Major, USAF, BSC
Chief, Industrial Hygiene Branch

Approved by:

ARTHUR P. CALDWELL, Colonel, USAF, BSC
Chief, Consultant Services Division

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ABSTRACT

This report presents the results of the testing and evaluation (T&E) of American Cleaning Equipment Corporation's MRS-3 Minuteman Mercury Recovery System. The report does not cover the effectiveness of the MRS-3 to remove or clean up mercury spills. Results of the T&E indicate the MRS-3 does not create a health hazard due to mercury vapor exposure and is acceptable for use in Air Force dental clinics.

The charcoal filter inside the MRS-3 absorbs the mercury that enters the unit. This filter keeps the leakage of mercury vapors from the unit assembly and exhaust to a minimum. For mercury spill situations the filter was effective for 129 hours of unit operation. For normal operations the filter was effective for duration of this phase of the T&E (176 hours of unit operation).

BACKGROUND

The Dental Investigation Service, USAFSAM, Brooks AFB, has outlined the need for a vacuum unit to be used in the Air Force dental clinics. The unit must be capable of effectively picking up mercury and at the same time not redistribute mercury vapors throughout the dental clinic during normal operations or mercury spill situations.

The Dental Investigation Service selected the MRS-3, Minuteman Mercury Recovery System, product of American Cleaning Equipment Corporation as the mercury vacuum to be used for T&E.

PURPOSE

The USAF OEHL/ECH was requested by the Dental Investigation Service to perform the T&E on the MRS-3 for possible health hazards due to exposures of mercury vapors.

DESCRIPTION OF MRS-3

The MRS-3 specifications and filtering system are described below. The specifications provided by the manufacturer are as follows:

120 Volts, 50/60 Hz, AC/DC
Max. amp. draw: 13.0 (1480 watts)
Max. static lift (sealed orifice): 110" H_2O
Max. air flow (2" diameter orifice): 115 CFM and 4.6 "H_2O
Nominal tank capacity: 15 gal
All figures are $\pm$ 10%.

The MRS-3 filtering system consists of: separator/trap, inside collector bag, dacron filter bag, impact filter, high efficiency particulate absolute (HEPA) filter, and a charcoal filter.

The specification sheet is shown in Drawing 1 and an enlarged view of the MRS-3 and its filters is shown in Drawing 2.

DESCRIPTION OF SAMPLING EQUIPMENT

Direct-reading air samples were obtained with the use of the Bacharach Mercury Vapor Sniffer MV-2, and Jerome's Mercury Vapor Analyzer 401 Monitor and Dosimeter Coil.

Indirect readings were obtained by air sampling with hopcalite tubes and subsequent analysis by the USAF OEHL Analytical Services Division.

TEST AND EVALUATION PROTOCOL

Objectives and Test Parameters

The objectives of the T&E were based upon the two modes of operation for the unit: (1) Normal operation - consisting of using the unit for daily vacuuming of dental clinics; (2) Mercury spills - consisting of using the MRS-3 as an additional tool for the cleanup operations of mercury spills in dental clinics. Phase I and II testing protocols were used to simulate the two environments: normal operation and mercury spills.

During Phase I, normal operation, a controlled generating system generated an average mercury vapor concentration of 0.013 mg/m^3. This concentration of mercury vapors was vacuumed by the unit.

Phase II, mercury spill situation, was designed to simulate the accidental mercury spills in dental treatment rooms (DTR). These spills would most likely be less than two pounds of mercury, which is the normal size of mercury dispensers used in dental clinics. Spillage would result in the mercury being scattered over the floor creating pockets of high mercury concentrations at floor level.

During Phase II, a half pound of mercury was vacuumed every 30 seconds until the equivalent of two pounds was collected. The MRS-3 was allowed to continue operating for a period of time to insure complete collection of mercury.

Sampling Description

Air sampling was accomplished during the operational and storage modes of the MRS-3 vacuum.

During the operational mode, indirect (hopcalite) air sampling was periodically taken at the separator/trap, adapter assembly and exhaust of the MRS-3. These air samples were collected to determine if any mercury vapor leakage occurs during the operation of the unit.

Continuous direct (MV-2) monitoring of mercury vapor level was accomplished at the exhaust of the unit to determine the breakthrough point. Life of the charcoal filter is determined from the number of hours reached before the concentration of mercury vapors can be measured on the top side of the charcoal filter (breakthrough point). During the T&E, the unit was periodically disassembled and measurements were obtained from the top and bottom sides of the HEPA and charcoal filter.

During the storage mode, indirect (hopcalite and dosimeter coil) air sampling was periodically taken at the separator/trap, adapter assembly and exhaust of the MRS-3. These air samples were collected to determine if any mercury vapor leakage occurred during the storage mode of the unit.

During Phase I, indirect air sampling was performed during the operational and storage modes, at the separator/trap, adapter assembly and exhaust of the MRS-3 vacuum unit. Continuous monitoring of the exhaust was accomplished. Direct air samples were taken at the top and bottom sides of the HEPA and charcoal filters.

During Phase II, indirect air sampling was performed during the storage mode at the separator/trap, adapter assembly and exhaust of the MRS-3 vacuum unit. Continuous monitoring of the exhaust was accomplished. Direct air samples were taken at the top and bottom sides of the HEPA and charcoal filters. Indirect air sampling during the storage mode of Phase II was not required because of the low concentrations of mercury vapors found in Phase I sampling.

A new charcoal filter was installed in the vacuum unit before the start of Phase II.

RESULTS

Phase I

Normal Operation. The MRS-3 was operated for 176 hours as shown on the units elapsed time meter. Breakthrough point of charcoal filter #1 was never reached during this phase of T&E. During the operation of the MRS-3, mercury vapor levels found at the separator/trap, adapter assembly and exhaust are summarized in Table 1. Mercury vapor levels found while the MRS-3 was in a storage situation are summarized in Table 2. Results of direct air sampling of the top and bottom sides of the HEPA and charcoal filters are summarized in Table 3.

Phase II

Spill Situations. The MRS-3 was operated for 129 hours, as shown on the units elapsed time meter, with 322 pounds of mercury being passed through the unit. Breakthrough point of charcoal filter #2 did occur within 129 hours. Mercury vapor concentrations found while the MRS-3 was in the storage situation are summarized in Table 4. Results of direct air sampling of the top and bottom sides of the HEPA and charcoal filters are summarized in Tables 5 and 6.

DISCUSSION AND CONCLUSIONS

During the T&E of the MRS-3 unit the following items were discovered:

The inside of the vacuum hose consists of a corregated liner. Some of the vacuumed mercury can be trapped by the corregations inside the hose.

The separator/trap is a metal cylindrical chamber with a baffle insert between the inlet and outlet ports. This chamber is threaded at the large opening. At this opening a glass jar is screwed into the metal chamber. After unscrewing the jar several times, pieces of glass thread were broken off. Also, mercury clings to the metal and glass threads. As the jar is removed mercury can easily fall off the threads onto the floor. The glass jar is very vulnerable to breakage. As can be seen in Drawing 3, the glass jar protrudes away from the unit increasing the chance of breakage. If the jar breaks, a new source of mercury vapors is created.

The MRS-3 modules are secured together by two spring loaded fasteners as shown in Drawing 4. After disassembling and assembling the modules several times, the fastener springs became weak. This could result in leakage of mercury vapor from between the contact surfaces of the two modules.

The vacuum hose fits over the input port of the separator/trap assembly. Mercury can become trapped at the point of contact between the vacuum hose and input port of the separator/trap assembly creating an additional potential source of mercury leakage.

RECOMMENDATIONS

If the American Cleaning Corporation Minuteman Mercury Recovery System vacuum cleaner is selected for use in dental clinics the following recommendations should be considered:

1. Quarterly inspections of the vacuum unit for leakage of mercury vapors be performed during the first year's use.

2. Do not order the vacuum unit with a HEPA filter. The HEPA filter does not control or collect mercury vapors. The purpose of the HEPA is for controlling and collecting of dust and particulates. Dust and particulates are not a problem in dental clinics.

3. Replace the charcoal filter quarterly for the first year of use. Before each replacement, mercury vapor measurements from top side of the charcoal filter and number of hours on the elapsed time meter should be recorded. After the first year, the dental clinic and base bioenvironmental engineering managers should review the past charcoal filter replacement record and determine a future charcoal filter replacement schedule.

4. Replace the paper and cloth filters bimonthly.

5. The base bioenvironmental engineering sections should provide disposal instructions of the mercury contaminated filters and contaminated mercury.

6. An instruction booklet should be de eloped containing information on procedures for monitoring of mercury vapor leakage, handling of mercury contaminated material, protective equipment to be used during filter change and detailed procedures for filter change.

Recommendations for specific problem areas mentioned in the Discussion and Conclusion Section are as follows:

1. The vacuum hose should be replaced with a smooth bore hose.

2. A nonbreakable, impermeable jar without threads, and a bail clamp (see Drawing 5) should replace the glass jar setup.

3. The spring tension of the spring loaded fasteners should be increased.

4. The vacuum hose should be able to fit inside, as opposed to over, the input port of the separator/trap assembly.

REFERENCE

TLVs for Chemical Substances, 1980, American Conference of Governmental Industrial Hygienists.

TABLE 1: UNIT OPERATING, FIRST FILTER, MERCURY VAPOR CONCENTRATIONS [mg/m^3]

Air Sampling Location	No. Hours on Unit											
	6	16	38	43	53	57	61	76	90	133	142	176
Separator/Trap	.001	.001	.0017	.0003	.0011	.001	.0003	.001	.001	.001	.0069	.003
Adapter Ass'y	.001	.001	.005	.001	.001	.001	.001	.001	.001	.001	.001	.0003
Exhaust	.0005	.0005	.0008	.001	.001	.001	.001	.001	.001	.001	.001	.0015

Note: The TLV - TWA is 0.05 mg/m^3 (Reference 1)

TABLE 2: UNIT STORAGE, FIRST FILTER, MERCURY VAPOR CONCENTRATIONS [mg/m^3]

Air Sampling Location	No. Hours on Unit				
	76	90	133	148	176
Separator/Trap	.001	.0004	.0002	.0069	.003
Adapter Ass'y	.0451	.001	.001	.001	.0015
Exhaust	.001	.001	.001	.001	.001

Note: The TLV - TWA is 0.05 mg/m^3 (Reference 1)

TABLE 3: CHARCOAL AND HEPA SAMPLING, FIRST FILTER, MERCURY VAPOR CONCENTRATION [mg/m^3]

Air Sampling Location	No. Hours on Unit												
	10	16	24	34	38	40	43	52	56	60	63	67	70
Top Side Charcoal Filter	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
Bottom Side Charcoal Filter	.001	.001	.007	.001	.009	.003	.003	-	.005	.01	.02	.005	-
Top Side HEPA Filter	.001	.001	.02	.003	.008	.001	-	.002	.02	.005	-	-	-
Bottom Side HEPA Filter	.003	.001	.04	.001	.003	-	-	-	-	-	-	-	-

Note: The TLV-TWA is 0.05 mg/m^3 (Reference 1)

(Continued) TABLE 3: CHARCOAL AND HEPA SAMPLING, FIRST FILTER, MERCURY VAPOR CONCENTRATIONS [mg/m^3]

Air Sampling Location	No. Hours on Unit											
	76	86	90	95	99	102	106	112	124	133	142	149
Top Side Charcoal Filter	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
Bottom Side Charcoal Filter	.004	-	.004	.015	-	-	-	-	-	.007	.005	.004
Top Side HEPA Filter	-	-	-	-	-	-	-	-	-	-	-	-
Bottom Side HEPA Filter	-	-	-	-	-	-	-	.007	-	-	-	-

Note: The TLV - TWA is 0.05 mg/m^3 (Reference 1)

TABLE 4: UNIT STORAGE, SECOND FILTER, MERCURY VAPOR CONCENTRATIONS [mg/m^3]

Air Sampling Location	No. Hours on Unit					
	1	2	5	7	57	129
Separator/Trap	.004	.002	.001	.002	.007	-
Adapter Ass'y	.012	.007	.061	.006	.008	.011
Exhaust	.006	.001	.004	.001	.014	.001

Note: The TLV - TWA is 0.05 mg/m^3 (Reference 1)

TABLE 5: CHARCOAL AND HEPA SAMPLING WITH BACHARACH MV-2, SECOND FILTER, MERCURY VAPOR CONCENTRATION [mg/m^3]

Air Sampling	No. Hours on Unit, Second Filter											
Location	.1	.2	.3	.5	.6	.7	.8	.9	1	1.1	1.2	4.9
Top Side Charcoal Filter	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
Bottom Side Charcoal Filter	.15	.35	.60	.55	.60	.68	.70	.73	-	-	.85	+1
Top Side HEPA Filter	.2	.4	+1	.55	.76	.73	.73	.98	-	-	+1	-
Bottom Side HEPA Filter	-	-	-	-	-	-	-	-	-	-	+1	-

Note: The TLV - TWA is 0.05 mg/m^3 (Reference 1)

(Continued) TABLE 5: CHARCOAL AND HEPA SAMPLING WITH BACHARACH MV-2, SECOND FILTER, MERCURY VAPOR CONCENTRATION [mg/m^3]

Air Sampling	No. Hours on Unit, Second Filter												
Location	5.7	6.6	9.7	10.1	10.5	11	16.6	33.4	33.8	34.1	40	56.5	56.9
Top Side Charcoal Filter	.001	.01	.001	.001	.001	.001	.003	.001	.003	.002	.001	.001	.002
Bottom Side Charcoal Filter	+1	-	.025	.01	.5	.5	.008	.024	.45	.54	.029	.005	.46
Top Side HEPA Filter	-	-	+1	.5	.53	-	.003	-	.40	.20	-	.002	-
Bottom Side HEPA Filter	-	-	_	_	-	-	-	-	-	-	-	-	-

Note: The TLV- TWA is 0.05 mg/m^3 (Reference 1)

TABLE 6: CHARCOAL AND HEPA SAMPLING WITH JEROME 401 MONITOR AND DOSIMETER COIL, SECOND FILTER MERCURY VAPOR CONCENTRATION [mg/m^3]

Air Sampling	No. Hours on Unit					
Location	78.6	82.2	83.13	100.2	123.3	129.3
Top Side Charcoal Filter	.003	.001	.003	.004	.004	.06
Bottom Side Charcoal Filter	.006	.004	.006	.004	.006	.167
Top Side HEPA Filter	.008	.025	.042	.004	.06	-
Bottom Side HEPA Filter	-	.036	-	-	-	-

Note: The TLV - TWA is 0.05 $mg/^3$ (Reference 1)

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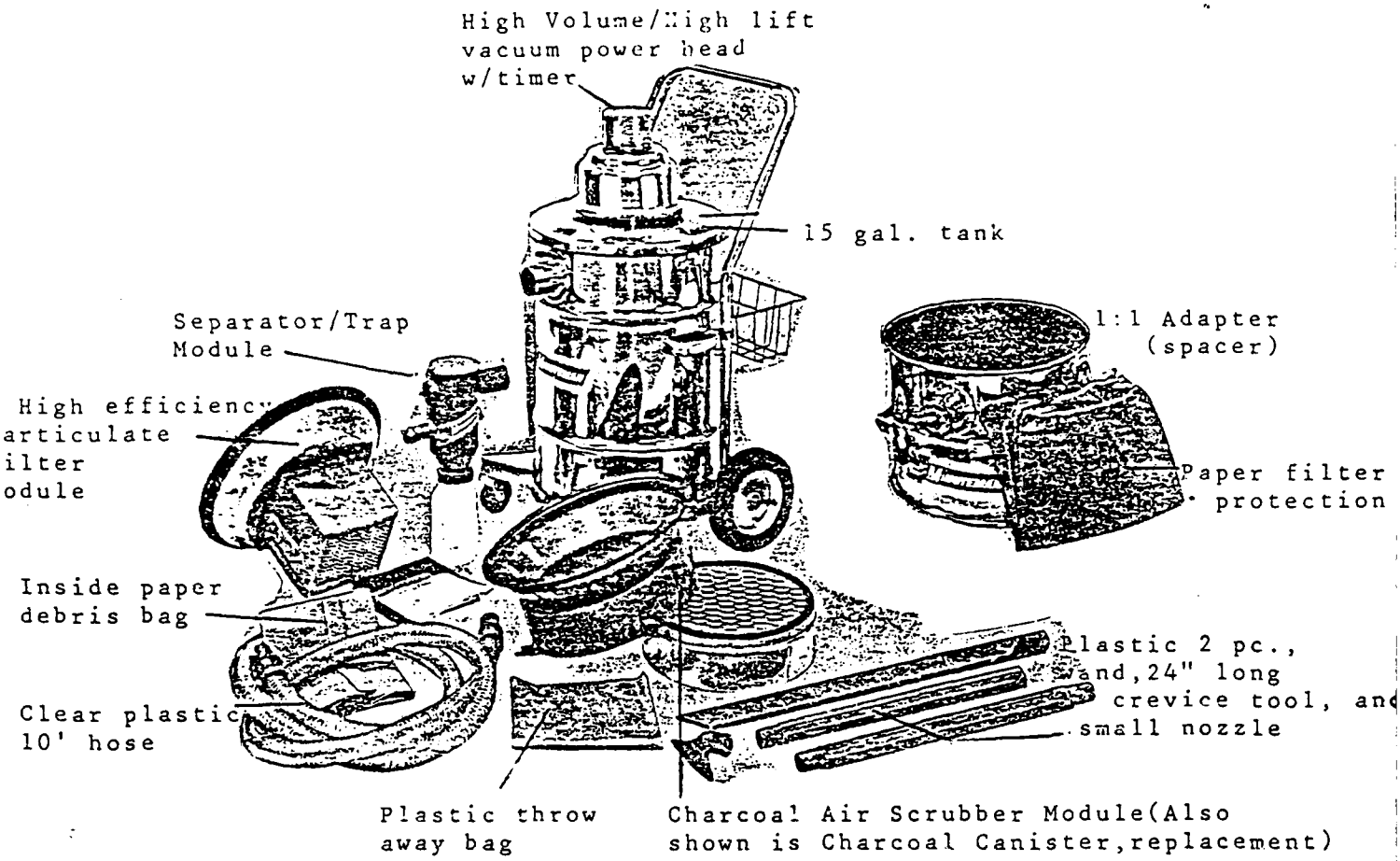
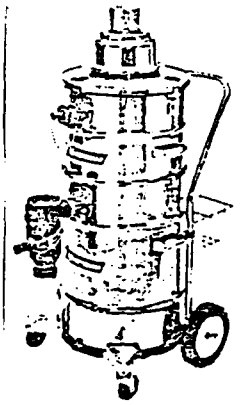




MRS-3 Basic unit plus absolute filter for maximum protection against mercury vapors and particulate matter

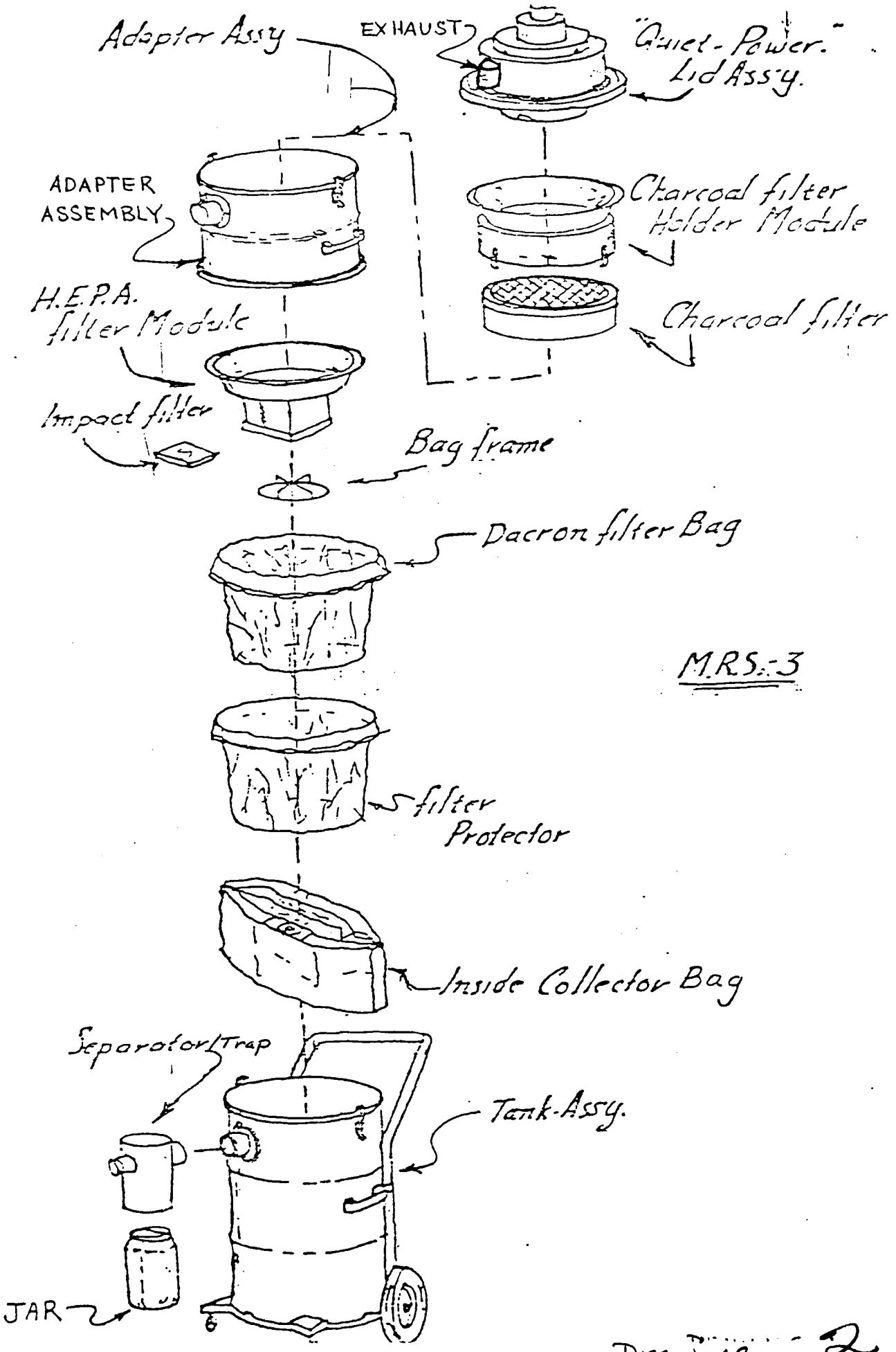
This system includes liquid trap, disposable paper bag, paper filter protector, critical filter and charcoal filter module.

SPECIFICATIONS

120 volts, 50/60 Hz, AC/DC
Max. amp draw: 13.0 (1480 Watts)
Max. static lift (sealed orifice): 110" H_2O
Max. air flow (2" dia. orifice): 115 C.F.M. (@ 4.6" H_2O)
Nominal tank capacity: 15 gal.
All figures + or − 10%

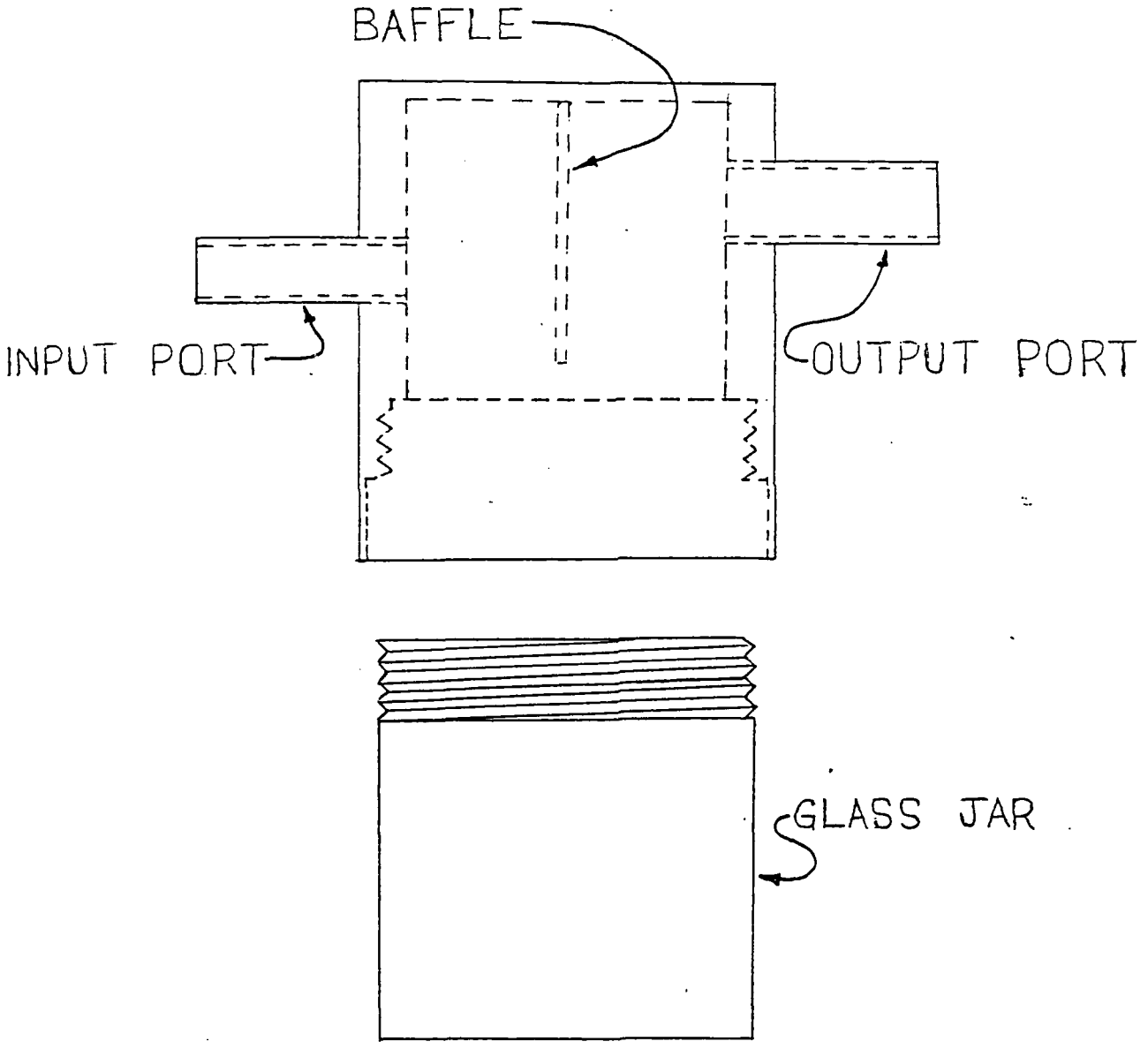
The Minuteman MRS Mercury Recovery System

Drawing-1

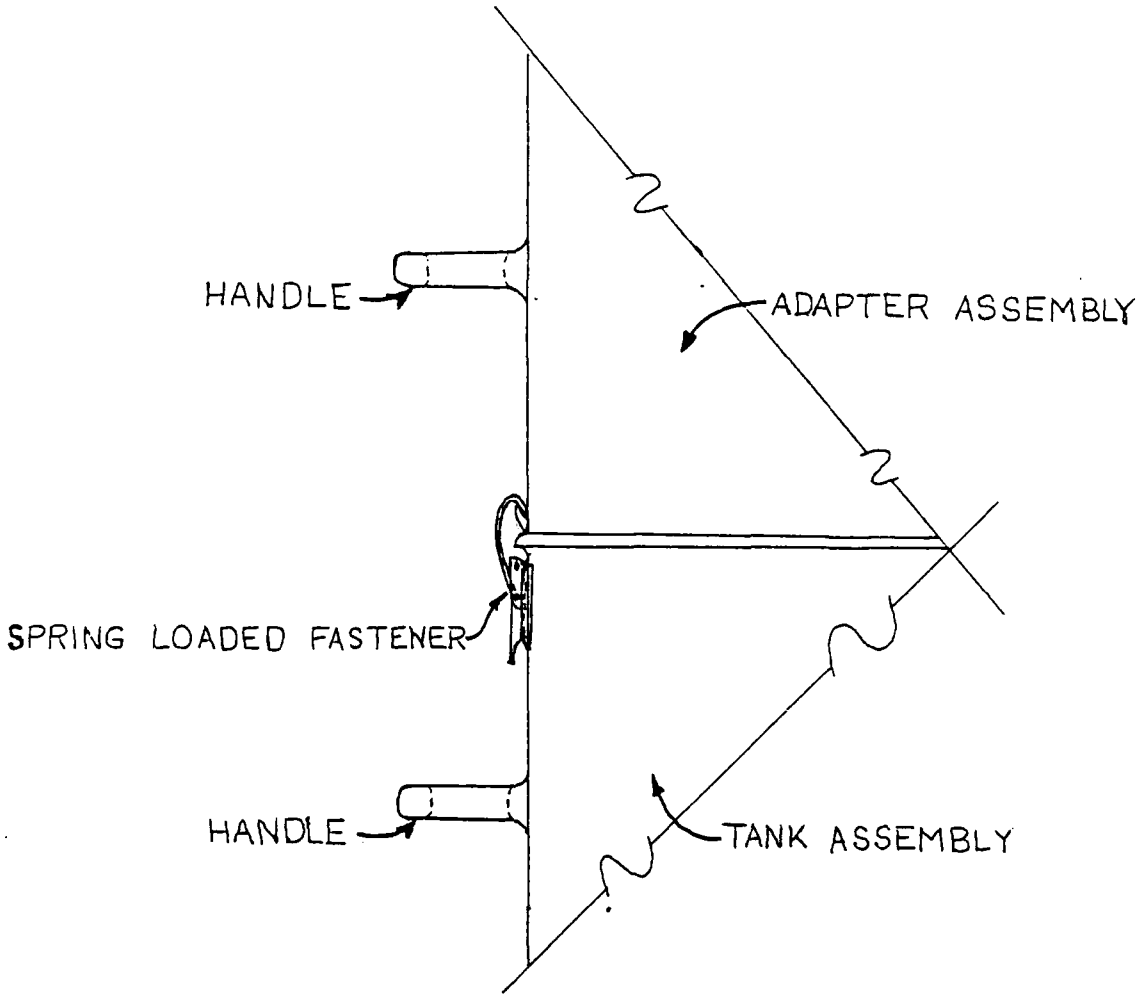

Adapter Assy
EXHAUST
"Quiet-Power" Lid Assy.
ADAPTER ASSEMBLY
Charcoal filter Holder Module
H.E.P.A. filter Module
Charcoal filter
Impact filter
Bag frame
Dacron filter Bag
M.R.S.-3
filter Protector
Inside Collector Bag
Separator/Trap
Tank-Assy.
JAR

Drawing - 2

SEPARATOR/TRAP ASS'Y



DRAWING - 3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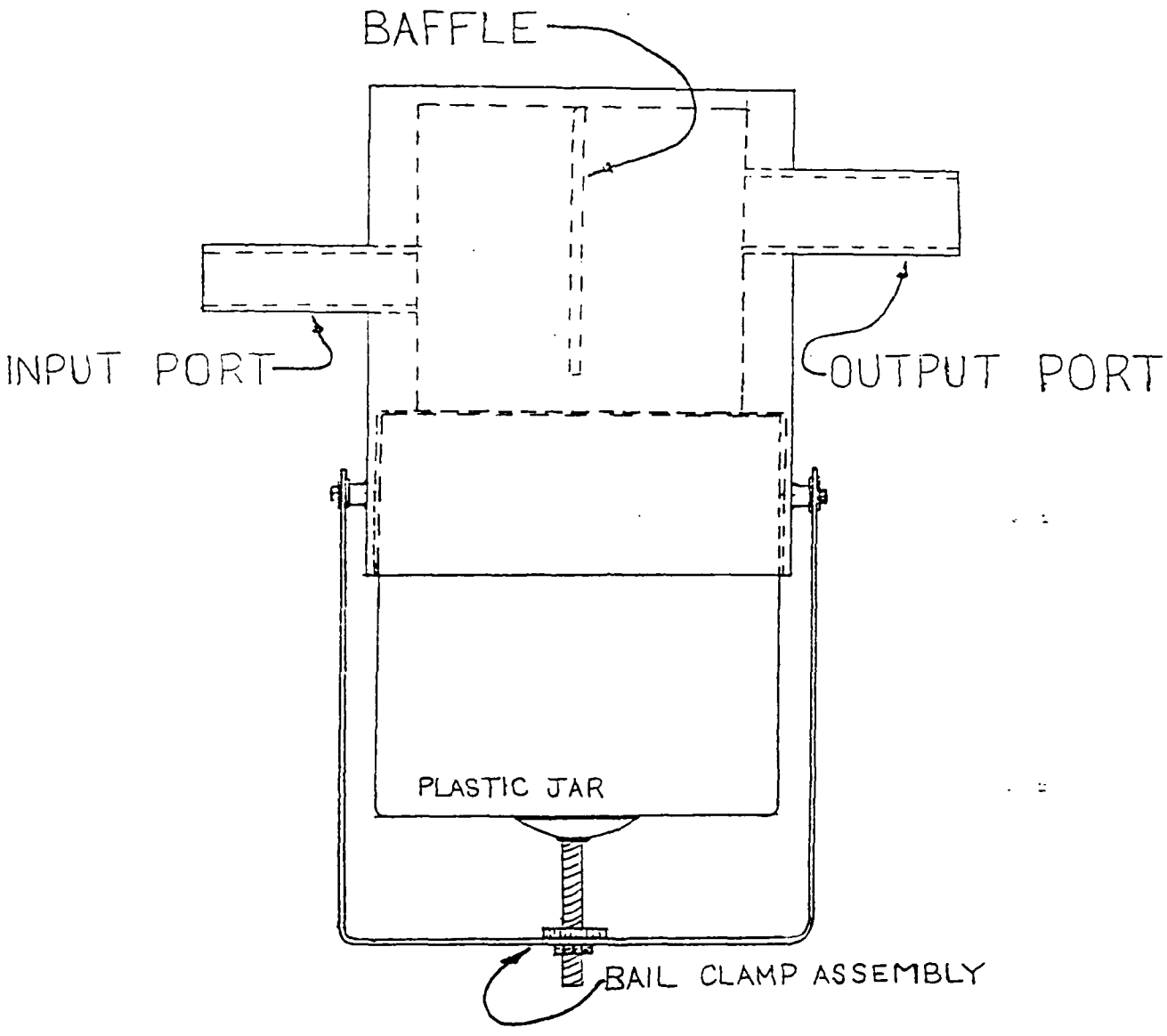
SPRING LOADED FASTENER
HANDLE
TANK ASSEMBLY

DRAWING - 4



RECOMMENDED DESIGN FOR
SEPARATOR / TRAP ASS'Y

DRAWING - 5

REFERENCE

TLVs for Chemical Substances, 1980, American Conference of Governmental Industrial Hygienists.